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1. Your reference

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2. Patent application number
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3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

ANDREW PHILLIP CHURCHILL
11 McDONALD DRIVE
ELLON
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AB41 8BD

Patents ADP number *(if you know it)*

631770002 Rdes

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

BYPASS TOOL

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

CRUIKSHANK & FAIRWEATHER
19 ROYAL EXCHANGE SQUARE
GLASGOW G1 3AE

Patents ADP number *(if you know it)*

547002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Number of earlier application	Date of filing *(day / month / year)*

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a) any applicant named in part 3 is not an inventor, or
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Description	15
Claim(s)	–
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Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
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11\. I/We request the grant of a patent on the basis of this application.

Signature CRUIKSHANK & FAIRWEATHER Date 14/07/99

12\. Name and daytime telephone number of person to contact in the United Kingdom: Andrew Shanks - 0141-221-5767

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DOWNHOLE TOOL

The present invention relates to a downhole tool which is actuatable between at least two tool configurations. In particular, but not exclusively, the present invention relates to a downhole tool comprising a bypass tool for location in a borehole of a well, wherein the bypass tool is actuatable between a closed configuration and an open configuration in response to the flow of fluid through the borehole.

Bypass tools are typically disposed within a borehole of, for example, an oil well, for selectively allowing fluid communication between a bore defined by a tubular string disposed in the borehole, and an annulus defined between an outer wall of the tubing string and an inner wall of the borehole. Typical known assemblies are often complex, comprising many interconnected components, and often require, for example, multiple fluid pressure cycles of fluid in the borehole to actuate the bypass tool between two or more distinct tool configurations.

It is amongst the objects of the present invention to obviate or mitigate at least one of the foregoing disadvantages.

Accordingly, the present invention provides a downhole tool for disposition in a borehole of a well, the tool being configurable in at least a first and a second tool configuration, the tool comprising:

a tubular housing for running into a borehole on a tubing string;

a tubular sleeve assembly for disposition within the tubular housing and axially movable therein and including fluid pressure responsive means for actuating the tool between said first and second tool configurations; and

means for maintaining said sleeve assembly in a selected one of said first and second tool configurations.

Thus the present invention may allow a downhole tool to be disposed in a borehole, which tool may be actuated between two or more tool configurations by supplying fluid to the tool in the borehole and by varying the flow rate of the fluid through the borehole.

Preferably, the downhole tool is a bypass tool. The bypass tool may be in a closed configuration in the first tool configuration and an open configuration in the second tool configuration. The tubular housing may form part of a lining, casing, or drill string or any other tubing string for disposition in the borehole.

The tubular housing of the bypass tool may comprise at least one bypass port extending through a wall of the housing. The at least one bypass port may extend radially through the wall of the housing. The sleeve assembly may be axially movable to selectively move to the open configuration, to allow fluid communication between the housing interior wall, and an annulus defined by an outer face of the housing wall and the borehole wall.

The fluid pressure responsible means may include a

flow restriction, such that flow of fluid induces a pressure differential, and therefore a fluid pressure force, across the restriction. Alternatively, said means may define a differential piston with, for example, one piston face experiencing internal housing pressure and another face experiencing annulus pressure, such that an increase in internal pressure will actuate the tool.

The tubular sleeve assembly may comprise a control sleeve mounted in the housing and a flow restriction for location within the control sleeve for restricting the flow of fluid through the control sleeve. Preferably, the restriction is defined by an insert which may be dropped or lowered from the surface into the tubing string and may travel through the string and engage the control sleeve of the tubular sleeve assembly. Fluid flow through the borehole and through the flow restriction creates a force acting axially across the flow restriction, and thus on the control sleeve, urging the sleeve assembly to move axially.

Alternatively, the tubular sleeve assembly may comprise a control sleeve mounted in the housing, the control sleeve including a flow restriction for restricting the flow of fluid through the control sleeve. The flow restriction may an annular, radially inwardly extending ring which, together with the control sleeve, defines a nozzle. The housing may further comprise a releasable connection, preferably a shear connection, such as one or more shear pins, for engaging the control sleeve and maintaining it in a selected one of said first and second

tool configurations. The bypass tool may further comprise a flow restriction engaging insert, such as a ball, for engaging the flow restriction of the control sleeve. Thus, in response to pressurisation of the fluid in the tubing string above the insert, a pressure force acting across the insert may be caused to move the tubular sleeve assembly axially downwardly to shear the pins. As noted above, the flow restriction engaging insert may be a ball, and may be injected into the tubing string at the surface and may travel through the string bore to engage the flow restriction. Preferably, the ball is deformable to allow the ball to be forced through the flow restriction in response to an increase in the pressure of the fluid in the tubing string above the ball.

In a further alternative arrangement, the tubular sleeve assembly may comprise a control sleeve disposed adjacent to an inner wall of the housing and a release member, preferably a release sleeve, for disposition in the control sleeve to allow axial movement of the tubular sleeve assembly. Locking means such as spring loaded locking dogs may be provided extending substantially radially inwardly from the wall of the housing, to engage the control sleeve and maintain the control sleeve in a selected one of said first and second configurations. The release sleeve may be inserted into the tubing string at the surface and may travel down the string to engage the control sleeve. The release sleeve may include a locking dog-engaging surface for engaging and releasing the locking

dogs and allowing the control sleeve to move axially in response to fluid pressure force, for example a differential pressure across the housing wall.

Preferably, the downhole tool further comprises indexing means for selectively allowing actuation of the tool between said first and second tool configurations. The indexing means may comprise a groove extending around an outer circumference of the tubular sleeve assembly, and a pin extending radially inwardly from an inner surface of the housing for engaging the groove. Of course, in alternative arrangements the groove may be defined by the housing, and the pin mounted on the sleeve assembly. The pin and groove may co-operate to rotate the tubular sleeve assembly when it is moved axially. Conveniently, the groove is a notched groove defining a first and second axial pin rest position. Preferably, the notched groove defines a plurality of first and second axial pin rest positions. The first axial pin rest position may correspond to a valve open configuration and the second axial pin rest position may correspond to a valve closed configuration. The notched groove may further define a plurality of third axial pin rest positions for allowing actuation of the tool to an intermediate configuration between said first and second tool configurations, and which intermediate position may provide a further tool function, or may correspond to the function provided by one of the first or second tool configurations. The third axial pin rest positions may be provided between second

axial pin rest positions. Thus the groove and pin may allow the tool to be disposed in the intermediate configuration alternatively when the pressure in the borehole is increased.

The maintaining means may comprise a spring for applying a force upon the sleeve assembly. The spring may be a compression or tension spring. Preferably, the spring is disposed in an annular cavity between the housing and the sleeve assembly, to impart an upward force upon the sleeve assembly, to maintain it in a closed configuration.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1A is a longitudinal cross-sectional view of a downhole tool in accordance with an embodiment of the present invention;

Figure 1B is a schematic illustration of a pin and groove arrangement forming part of the downhole tool of Figure 1A;

Figure 2 is a longitudinal cross-sectional view of a downhole tool in accordance with an alternative embodiment of the present invention; and

Figure 3 is a longitudinal cross-sectional view of a downhole tool in accordance with a further embodiment of the present invention.

Referring firstly to Figure 1, there is shown a longitudinal cross-sectional view of a downhole tool in accordance with an embodiment of the present invention, the

downhole tool indicated generally by reference numeral 10. The downhole tool 10 forms part of a drill string (not shown) run into a borehole (not shown) of an oil well, and is coupled at its upper and lower ends to sequential sections of drill string tubing via threaded joints, in a fashion known in the art.

The downhole tool 10 shown in Figure 1A is a bypass tool comprising a tubular outer housing 12, a tubular bypass sleeve 14, a tubular flow restriction insert 16, a bypass sleeve spring 18 and a pin and groove assembly indicated generally by reference numeral 19.

The tubular outer housing 12 includes flow ports 20 extending radially through a wall 22 of the housing 12, and spaced circumferentially around the housing 12. For clarity, only two such ports 20 are shown in Figure 1A, however it will be appreciated that any suitable number of such flow ports 20 may be provided in the housing 12. The housing 12 has an inner face 24 and the internal diameter of the housing 12 defined by the inner face 24 varies along the length of the housing 12 from top to bottom. In particular, an upper portion 26 of the housing 12 is of a first general internal diameter, whilst a lower portion 28 of the housing 12 is of a smaller, second general internal diameter. This enables the housing 12, in conjunction with the tubular bypass sleeve 14, to define an annular cavity 30 in which the bypass sleeve spring 18 is located, as will be described in more detail below.

The tubular bypass sleeve 14 includes flow ports 32,

and is axially movable within the housing 12, to enable the flow ports 20 of the housing 12 and the flow ports 32 of the sleeve 14 to be aligned. This allows communication between an internal tool bore 34 and an annulus defined between an outer face 36 of the housing 12 and the borehole wall.

The bypass sleeve spring 18 is a compression spring and is disposed in the cavity 30 between a washer 38 and a radially outwardly extending shoulder 40 of the bypass sleeve 14. In the position shown in Figure 1A, the bypass sleeve spring 18 maintains the bypass sleeve 14 in a closed configuration wherein an upper end 42 of the bypass sleeve 14 is disposed adjacent to the upper end of the housing 12.

When it is desired to move the bypass sleeve 14 axially downwardly against the force of the bypass sleeve spring 18, to align the flow ports 20 and 32, the tubular flow restriction insert 16 is inserted into the drill string at the surface and carried down the internal string bore 34 until it engages the bypass sleeve 14 as shown in Figure 1A. The flow restriction insert 16 includes annular, radially inwardly extending shoulders 44 and 46, which define first and second restrictions respectively. These restrictions to the flow of fluid through the internal bore 34 are such that, when fluid flows through the flow restriction insert 16, a pressure differential is created across each restriction and a downward axial force is imparted upon the flow restriction insert 16 by the flowing fluid.

The flow rate of the fluid through the string and tool is increased until the force upon the flow restriction insert 16 becomes sufficiently large to overcome the force imparted upon the bypass sleeve 14 by the bypass sleeve spring 18. The flow restriction insert 16 and the bypass sleeve 14 then move axially downwardly, compressing the spring 18 until the bypass sleeve 14 reaches the end of its travel, wherein a lower end 44 is disposed adjacent to the lower end of the housing 12. The flow ports 20 and 32 are then aligned, allowing fluid communication between the internal bore 34 and the annulus bore. This may allow operations such as a "clean-up" operation to be carried out, wherein drill cuttings or the like lying in sections of the borehole may be entrained with and carried back to the surface by the fluid flowing through the aligned bypass ports 32 and 20.

When it is desired to move the bypass sleeve 14 back to the closed configuration shown in Figure 1A, the flow rate of the fluid flowing through the internal bore 34 is reduced, until the fluid pressure force applied by the fluid upon the bypass sleeve 14 and the flow restriction insert 16 drops below the force imparted upon the bypass sleeve 14 by the spring 18. The bypass sleeve 14 is then moved axially upwardly by the spring 18 acting against the shoulder 40 of the bypass sleeve 14.

Referring now to Figure 1B, there is shown a schematic illustration of the pin and groove arrangement 19 shown in Figure 1A. The arrangement 19 includes an annular

circumferential extending groove 46 and a pin 48 though for clarity the groove 46 is shown as a planar groove. The groove 46 is notched or corrugated and defines a number of first pin rest positions 50a and 50b, a number of second pin rest positions 52, and a number of third pin rest positions 54. The second and third pin rest positions 52 and 54 are spaced alternately around the circumference of the bypass sleeve 14. The pin 48 is shown in Figure 1B in one of the first pin rest positions 50a where the bypass sleeve 14 is in the closed configuration of Figure 1A.

When the flow restriction insert 16 has been located in the bypass sleeve 14, and the flow rate of fluid through the internal bore 34 has been increased to counteract the force of the bypass sleeve spring 18, the bypass sleeve 14 moves axially downwardly until the pin 48 engages the sloping face 56 of the groove 46, which rotates the bypass sleeve 14. The pin 48 then becomes engaged in a slot 58 and comes to rest in a second pin rest position 52, where the bypass sleeve 14 is in the open configuration with the flow ports 20 and 32 aligned. When the flow rate of the fluid is reduced, the bypass sleeve spring 18 carries the bypass sleeve 14 axially upwardly, and the pin 48 moves over the surface of a sloping face 60 of the groove 46, rotating the sleeve 14, to one of the first pin rest positions 50b.

When the flow rate is again increased, the bypass sleeve 14 again moves axially downwardly. However, movement of the sleeve 14 is stayed when the pin 48 comes

to rest in the third pin rest position 54. Retention of the pin 48 in the third pin rest position 54 prevents the flow ports 20 and 32 from becoming aligned. When the fluid flow rate is next reduced, the pin 48 comes to rest in a first pin rest position 50a, whereupon subsequent increase of the fluid flow rate allows the bypass sleeve 14 to move fully axially downwardly, with the pin 48 engaged in the second pin rest position 52. Thus alternate opening of the bypass sleeve 14 may be achieved.

Referring now to Figure 2, there is shown a longitudinal cross-sectional view of a downhole tool in accordance with an alternative embodiment of the present invention, indicated generally by reference numeral 110. For ease of reference, like components with the downhole tool 10 of Figure 1A share the same reference numerals incremented by 100. The downhole tool 110 comprises a tubular outer housing 112, a tubular bypass sleeve 114, a bypass sleeve spring 118 and a pin and groove arrangement 119. Flow ports 120 extend through a wall 122 of the housing 112, and the bypass sleeve 114 includes flow ports 132 which may be aligned with the flow ports 120 of the housing 112, when the bypass sleeve 114 is moved axially downwardly, in a similar fashion to the bypass sleeve 14 of the downhole tool 10 of Figure 1A.

The bypass sleeve spring 118 is disposed in an annular cavity 130 between a washer 138 and a shoulder 140 of the bypass sleeve 114. However, the housing 112 includes shear pins 162 disposed in the wall 122, which extend radially

inwardly to engage the bypass sleeve 114. These shear pins 162 initially maintain the bypass sleeve 114 in a closed configuration as shown in Figure 2. Furthermore, the bypass sleeve 114 includes an annular, radially inwardly extending shoulder 164 which defines a flow restriction.

When it is desired to move the bypass sleeve 114 to the open configuration, where the flow ports 120 and 132 are aligned, a deformable ball 166 is inserted into the string bore and travels down to the tool 110 through the string bore 134. The ball 166 is carried in a fluid such as drilling mud through the internal bore 134, and engages in the shoulder 164 of the bypass sleeve 114. This effectively blocks the internal bore 134. When the pressure of the fluid in the internal bore 134 above the tool 110 is increased, this creates a considerable pressure force acting axially downwardly upon the ball 166 and thus upon the bypass sleeve 114, which compresses the spring 118 and shears the pins 162. This moves the bypass sleeve 114 to the open configuration.

However, the internal bore 132 remains blocked by the ball 166. A further increase of the pressure of the fluid above the ball 166 causes the ball 166 to deform plastically and to pass through the restriction created by the shoulder 164 of the bypass sleeve 114, allowing fluid to flow through the bypass tool 110, through the flow ports 132 and 120, and into the annulus bore. A ball catcher is provided (not shown) disposed in the part of the drill string tubing below the tool 110, to catch the ball 166

when it has passed through the bypass sleeve 114.

The pin and groove arrangement 119 includes a groove 146 and a pin 148 and functions in a similar manner to the pin and groove arrangement 19 shown in Figure 1B and described above. This therefore allows subsequent opening and closing of the bypass sleeve 114 in response to variations in the fluid flow rate.

Referring now to Figure 3, there is shown a downhole tool in accordance with a further embodiment of the present invention, indicated generally by reference numeral 210. For clarity, like components of the tool 210 with the tool 10 of Figure 1A share the same reference numerals incremented by 200.

The downhole tool 210 comprises a tubular outer housing 212, a tubular bypass sleeve 214, a bypass sleeve spring 218, a pin and groove arrangement 219 and a tubular release sleeve 268. The housing 212 includes flow ports 220 disposed in a wall 222 of the housing 212 and extending radially therethrough.

The tubular bypass sleeve 214 includes flow ports 232 and is mounted in the housing 212 to define an annular cavity 230, in which the spring 218 is disposed, between a washer 238 and a shoulder 240 of the housing 212. Elastomeric O-ring type seals 270 and 272 respectively are provided in the wall 222 of the housing 212, to seal the annular cavity 230 and isolate it from fluid in the internal tool bore 234. Also, bleed holes 274 extend through the wall 222 of the housing 212, to fluidly couple

the annular cavity 230 with the annulus of the borehole in which the tool 210 is disposed. Thus fluid in the annular cavity 230 experiences the same pressure as fluid in the annulus.

The bypass sleeve 214 includes openings 276 at its upper end 242, for engaging spring-loaded locking dogs 278, to retain the sleeve 214 in the closed configuration shown in Figure 3, whereby the flow ports 220 and 232 are mis-aligned. This prevents fluid communication between the internal bore 234 and the annulus bore. As shown in Figure 3, the leading end 280 of each locking dog 278 is chamfered. This allows the release sleeve 268 to be run into the borehole and located within the bypass sleeve 214 as shown in Figure 3, wherein a radially outwardly extending shoulder 282 of the sleeve 268 engages the leading end 280 of each locking dog 278. This compresses a spring 284 of each locking dog 278, forcing each locking dog 278 radially outwardly such that only the chamfered leading end 280 protrudes into the apertures 276.

To actuate the tool 210 to an open configuration, the pressure of fluid flowing through the internal bore 234 is increased such that the differential pressure between the fluid in the internal bore 234 and the fluid in the annulus bore increases. As the seal 270 defines a larger diameter than the seal 272, a net axially downward force is imparted upon the bypass sleeve 214 due to this differential pressure. This causes the actuating sleeve 268 and the bypass sleeve 214 to move axially downwardly. The locking

dogs 278 are disengaged from the engaging apertures 276 of the bypass sleeve 214 by the bypass sleeve 214 passing over the chamfered leading end 280 of each locking dog 278. This allows the flow ports 220 and 232 to be aligned, allowing fluid communication between the internal tool bore 234 and the annulus. When the pressure of the fluid in the internal bore 234 is reduced sufficiently such that the net force upon the bypass sleeve 214 falls below the restoring force of the spring 218, the spring 218 returns the bypass sleeve 214 to the closed configuration shown in Figure 3, by acting against the shoulder 240 of the housing 212.

The pin and groove arrangement 219 comprises a groove 246 and a pin 248 similar to the groove 46 and pin 48 of Figure 1B and the tool 10 of Figure 1A. When the bypass sleeve 214 returns to the closed configuration of Fig 3, the locking dogs 278 again engage the engaging holes 276 of the bypass sleeve 214 to retain the sleeve in the closed configuration, until the pressure of the fluid in the internal bore 234 is increased sufficiently to counteract the spring force 218 and force the locking dogs 278 radially outwardly.

Various modifications may be made to the foregoing within the scope of the present invention. For example, the downhole tool may be any tool capable of being actuated between first and second tool configurations, such as a valve assembly including a ball valve or a flapper valve.

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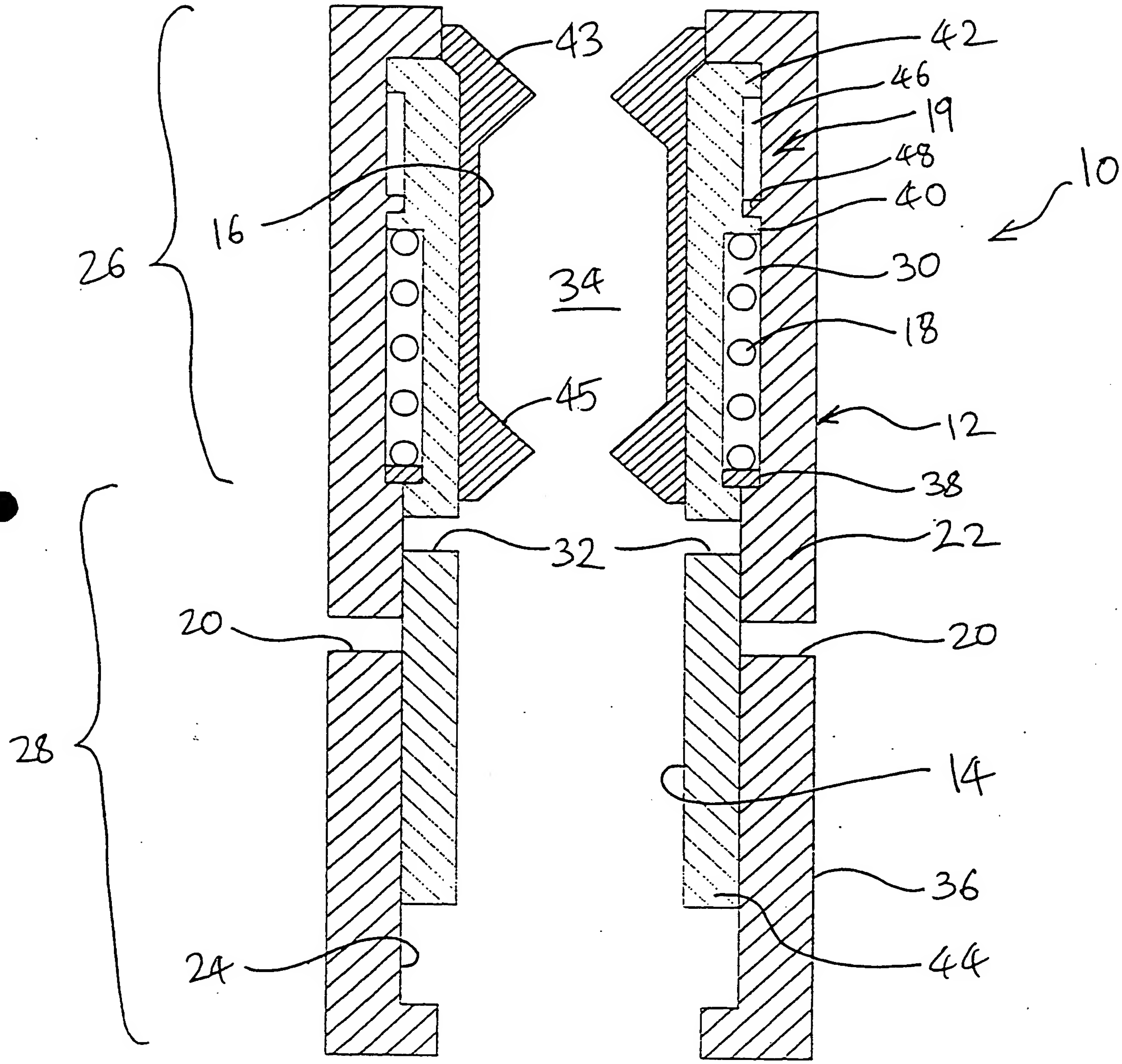
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FIG 1A

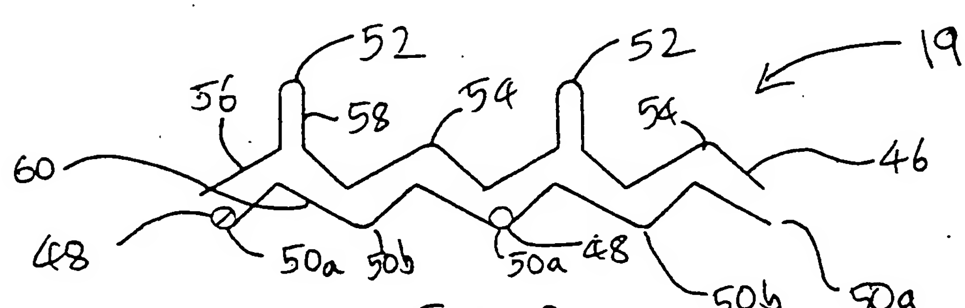
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FIG 1B

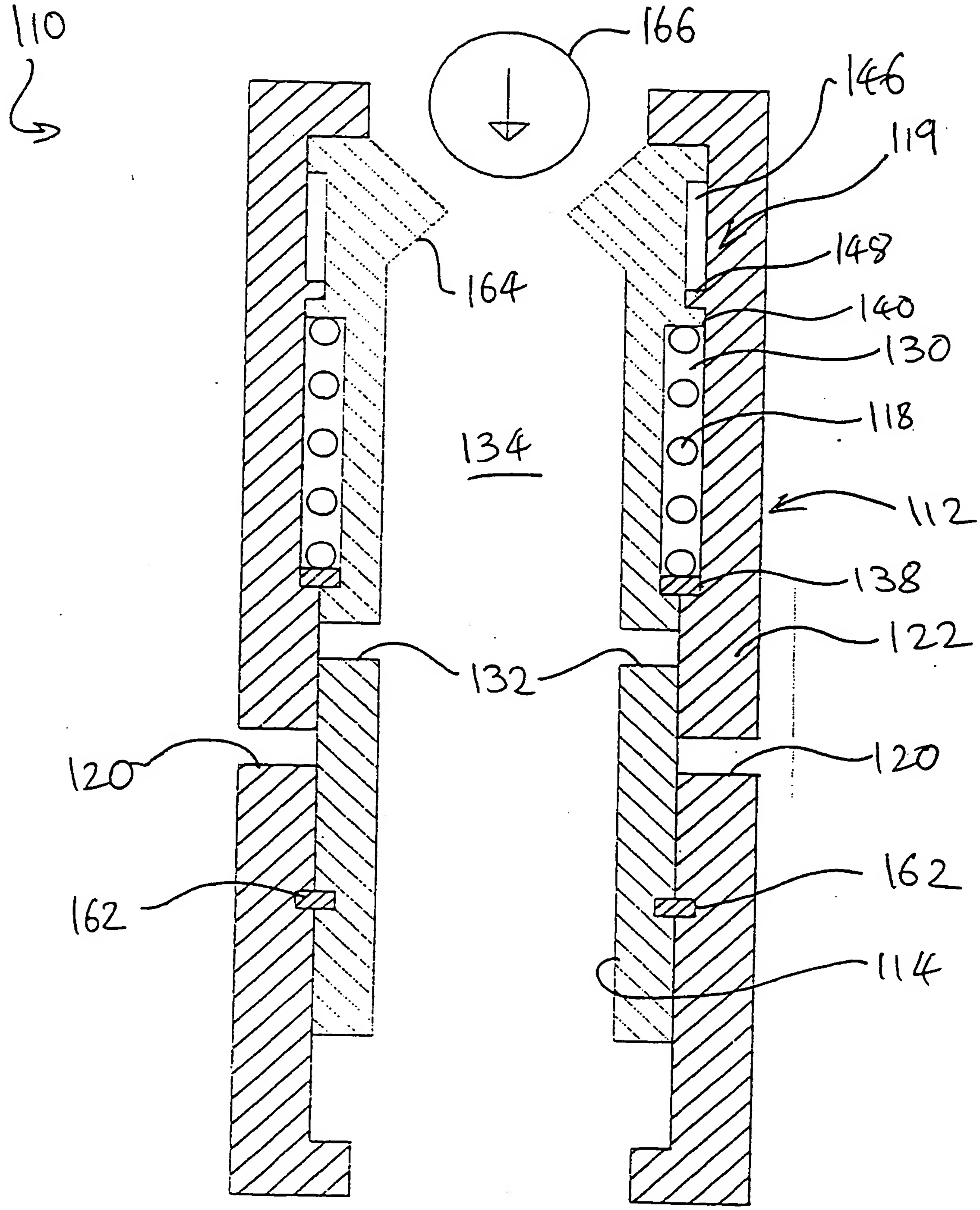
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FIG2

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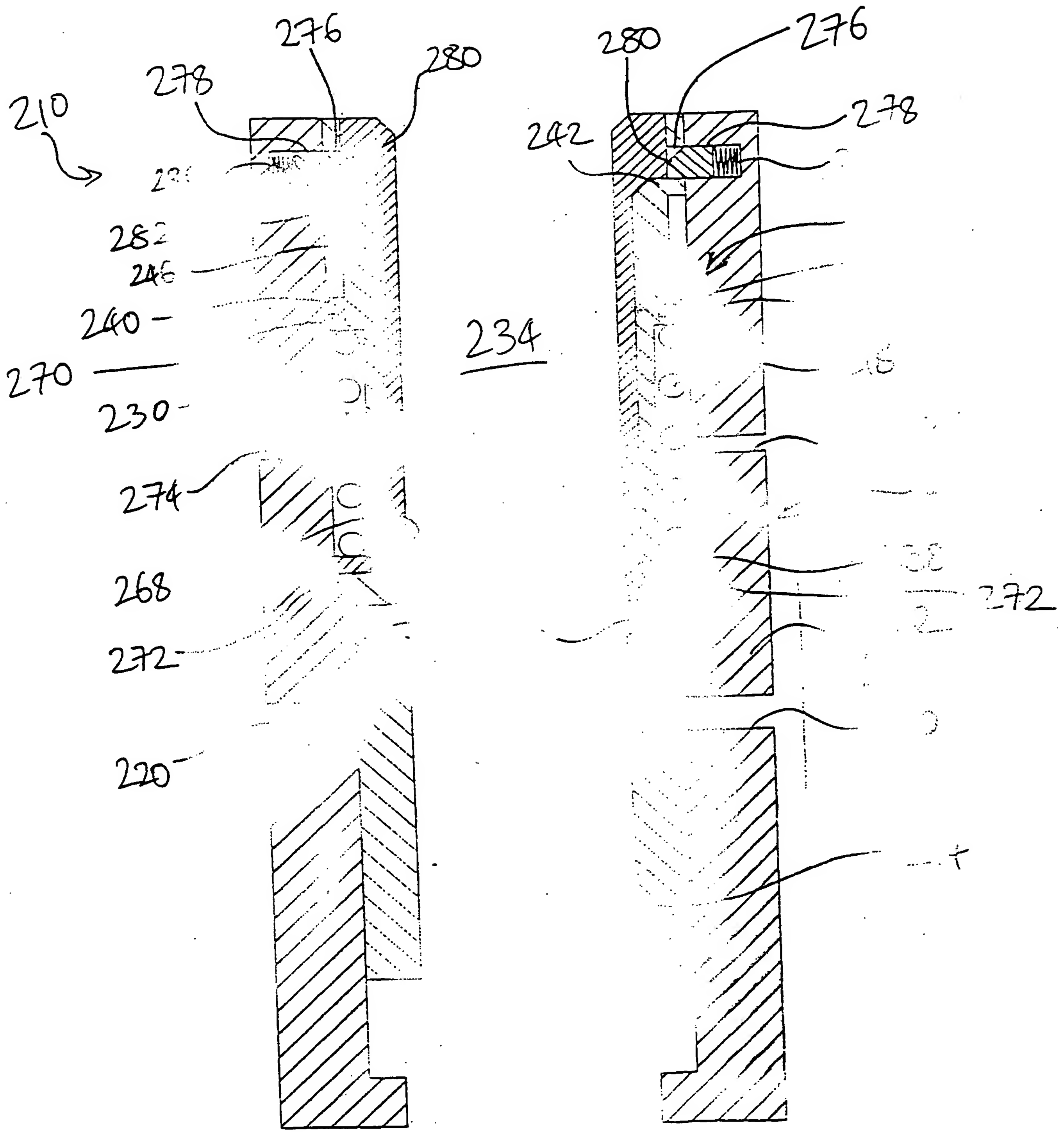

FIG3

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